

# P1.5 NOAA/ETL's Vertical-Profiling Cloud Radar and Radiometer Package



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## The MMCR Package – Integrating Active & Passive Remote Sensing of Clouds

Clouds play a vital role in climate and water resources by virtue of their ability to transform radiant energy and water phase in the atmosphere. NOAA/ETL designed and operates a self-contained instrument package which integrates active and passive remote sensing of clouds. The MMCR Package includes a millimeter-wave Doppler cloud radar, microwave and infrared radiometers, all vertically pointing and programmed for unattended operations within a single standard sea container. Standard surface meteorological instruments complete the suite. The MMCR package has been operated in land-based and ship-based research field experiment deployments from the Arctic to the Tropics.

The heart of the system is the “cloud” radar, which is capable of detecting most clouds to 20 km altitude with 45-m resolution, yielding intricately detailed images of cloud structure. The radar is essentially identical to the millimeter-wave cloud radars (MMCR) that ETL designed for the Atmospheric Radiation Measurement (ARM) program’s Cloud and Radiation Testbed sites. Although it transmits only 100 W of power, the radar achieves ultra-high sensitivity through the use of a high duty cycle, relatively large sampling time (1 s) and large antenna (1.8 m), with pulse-compression and other signal processing techniques. The dual-channel microwave radiometer yields continuous measurement of liquid water path and water vapor path (precipitable water vapor), while the IR measures the down-welling IR brightness temperature, which in the case of optically dense cloud layers gives a good approximation of cloud base temperature.

Radar backscatter, MW and IR emissions depend on hydrometeor properties in differing ways that can be exploited to estimate particle sizes, concentrations and mass content by combining data from the MMCR Package instruments through retrieval techniques developed at ETL.

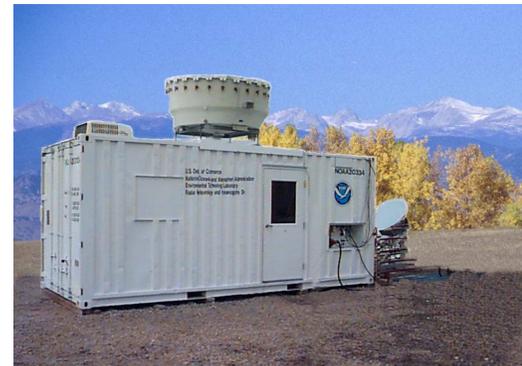


Photo of the MMCR Package in its 20-ft sea container in Colorado, showing the radar's antenna (on roof) and microwave radiometer's spinning reflector (right).

## A Hybrid Radar/Radiometer Cloud Research Tool

### Major Capabilities:

- \* Multi-wavelength remote sensing
- \* Unattended operation
- \* Transportable

### Primary Uses:

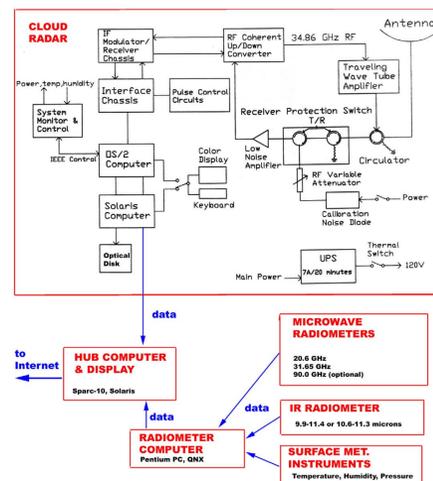
- \* Retrievals of profiles of hydrometeor sizes, concentrations, and mass content
- \* Monitoring cloud layer heights & thicknesses, water vapor and liquid water path, and cloud base temperature

### What's Next?

- \* Dual-polarization
- \* Major processor upgrade

## Data images and plots are sent to the Web in near-realtime

## Block Diagram of MMCR Package



## Instrument Package Characteristics

### --- Cloud Radar (MMCR) ---

*Major Capabilities:* Ultra-high sensitivity, Doppler

*Primary Uses:* vertical profiles of clouds, drizzle, snowfall, and very light rain.

*Frequency:* 34.86 GHz (wavelength = 8.7 mm)

*Transmit Power:* 100 W peak, with up to 25 W avg.

*Transmitter:* Traveling Wave Tube (>20,000 h life)

*Antenna:* 1.8-m diameter under tilted flat radome

*Beam Width:* 0.3 deg., circular

*Height Coverage:* ~20 km

*Resolutions:* 45 & 90 m; (255 and 495-m also available)

*Polarization:* transmit and receive H

*Sensitivity:* approx. -40 dBZ at height of 10 km

*Doppler Processing:* FFT

*Data System:* wind profiler POP with 2 computers

### --- Microwave Radiometer (MWR) ---

*Primary Uses:* Monitoring vertical water vapor path and liquid water path.

*Frequencies:* 20.6, 31.65, and 90.0 (optional) GHz

*Beam Width:* 5 deg.

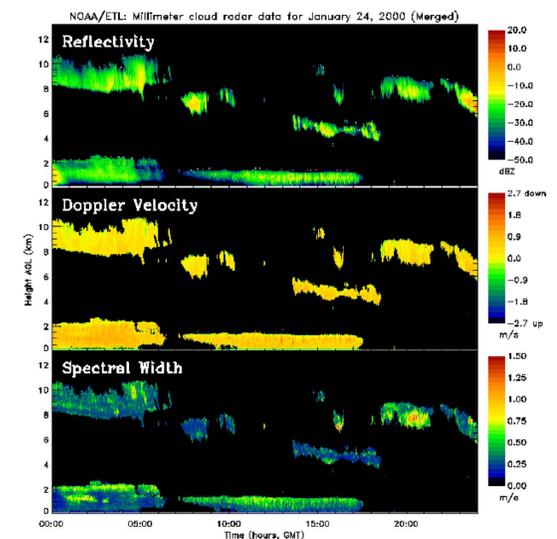
### --- IR Radiometer (IRR) ---

*Primary Uses:* Sensing the presence of cloud overhead, estimating base temp. of optically thick clouds.

*Wavelength:* 9.9-11.4 or 10.6-11.3 microns

*Field of View:* 2 deg.

## Winter Clouds Over Boston



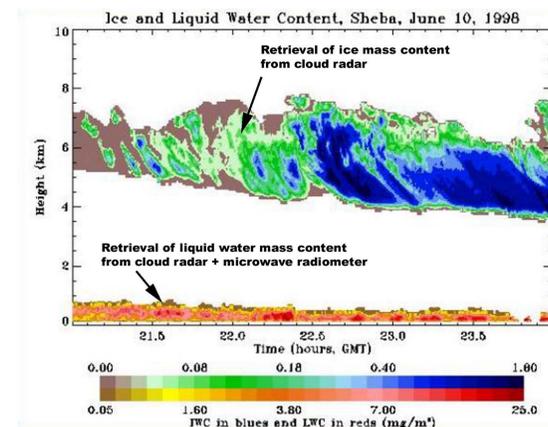
## Land-based and Ship-based Deployments



The MMCR Package aboard the Ron Brown Research vessel heading out to the eastern Pacific Ocean. (Photo by Michelle Ryan).



The MMCR Package at a wintry satellite communications study in Massachusetts.



## Summer Clouds Over the Arctic Ocean

## Retrievals of Microphysical Properties

Estimating Hydrometeor sizes and mass content ---

**Liquid Clouds:** cloud radar + microwave radiometer

**Ice Clouds (unobstructed):** cloud radar + infrared radiometer

**Mixed phase or obstructed ice clouds:** cloud radar alone

